Functional Requirement Specification

Project X Injector Experiment
Ion Source

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Revision History

Revision	Date	Section No.	Revision Description
0	1/4/2012	All	Initial Release.
1	6/19/2012	3	Wording
1	6/19/2012	4	Removed 'Machine protection' row in Table 1 and moved "beam turn-off time" (reworded from "beam shut-off time") to the 'Beam' list of requirements
2	7/19/2012	Title, 5	Changed name of Project X Project Engineer, added DocDB# to PXIE FRS reference

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1. Introduction:

Project X is a high intensity proton facility conceived to support a world-leading physics program at Fermilab.[1] Project X will provide high intensity beams for neutrino, kaon, muon, and nuclei based experiments and for studies supporting energy applications.
The Project X Injector Experiment (PXIE) will be a prototype Front End linear accelerator.[2] The construction and successful operation of PXIE at Fermilab will validate the concept for the Project X front end, thereby minimizing a large portion of the technical risk within Project X.

The PXIE Ion Source is the first component in this accelerator, and is designed to meet the Project X and PXIE requirements.

2. Scope:

The PXIE Ion Source assembly is a DC, H^- source designed to be capable of delivering 5mA (nominal) at 30keV to the Low Energy Beam Transport (LEBT) section. The Ion Source assembly consists of the ion source itself (H^- Volume-Cusp Ion Source) attached to a vacuum box, which allows for differential pumping. The vacuum box can also house a beam diagnostics station. The overall layout of the PXIE components is shown in Figure 1. In Project X two sources will be available on-line for redundancy, however in PXIE only one source will be used. Each source will be able to be isolated from the LEBT.

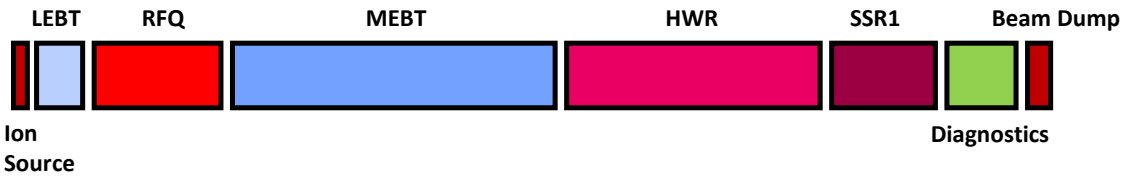

FIGURE 1: Major Subsystems in the PXIE Linac

3. Key Assumptions, Interfaces & Constraints:

The Ion Source will be installed initially in the PXIE facility. The source will conform to FNAL Engineering [4] and ES&H Standards [5]. All interfaces (power, instrumentation, vacuum, alignment, etc) will be discussed and agreed upon by the PXIE Project Scientist.

4. Requirements

TABLE 2: Ion Source Assembly Requirements

Beam		
	Ion type	H^-
	Nominal output kinetic energy	30 keV
	Kinetic energy stability	0.5% RMS
	Nominal beam current	5 mA
	Maximum beam current	10 mA
	Beam current stability [for frequencies f > 1 Hz (ripples)]	±5%
	Duty factor	100%
	Transverse emittance* over 1-10 mA current range	< 0.2 mm mrad
	Electron beam current at LEBT input	< 100 μA
	Turn-off time	< 1sec
Uptime		
	Mean time between maintenance (beam ON time)	> 350 hours
	Pre-conditioned ion source turn-on time[a]	< 10 min
	Ion source replacement time[b] (with closed-loop control circuit)	8 hours
Vacuum		
	Gas flow to LEBT (with beam on)	$\leq 4\times10^{-3}$ torr l s^{-1}

a - "Pre-conditioned ion source turn-on time" refers to the scenario in which, the on-line ion source fails, and the second ion source has been pre-conditioned i.e. demonstrated stable beam at nominal current - the source has then be maintained under vacuum with the gate valve closed. The operator needs to turn on the second ion source and configure the switching magnet such that the beam gets back online.
b - "Ion source replacement time" refers the scenario that the on-line ion source suddenly fails, but there is no pre-conditioned ion source available. The operator needs to either mount the 2nd ion source, or replace the filament of the failed source. In both cases, the system must be pumped down and the filament conditioned to the point where the closed-loop control system can provide stable beam downstream.
* The rms emittance is defined using the second moments of the particle distribution in phase space (e.g. $x-x'$) as follows: $\varepsilon_x = \left(\overline{x^2}\,\overline{x'^2} - \overline{xx'}^2\right)^{1/2}$. In modeling, it is based on 100% of particles; in experiments, it may be based on a truncated intensity (95-100%) to reduce the effect of far tails on the calculated emittance value.

5. References:

Documents with reference numbers listed are in the Project X DocDB:
http://projectx-docdb.fnal.gov

[1] Project X Functional Requirements Specification
Document #: Project-X-doc-658

[2] Project X Injector Experiment Functional Requirements Specification
Document #: Project-X-doc-980

[3] PXIE LEBT Functional Requirements Specification
Document #: Project-X-doc-912

[4] Fermilab Engineering Manual
http://www.fnal.gov/directorate/documents/FNAL_Engineering_Manual_REVISED_070810.pdf

[5] Fermilab ES&H Manual
http://www-esh.fnal.gov/pls/default/esh_home_page.page?this_page=15053